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Fatigue Life Prediction of Cold Forged Punch for Fastener Manufacturing by FEA

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***Abstract*:- This research will focus on the development and improvement of an innovated and integrated approach consists of an integrated CAD, FE analysis and analytical system to efficient determine the potential fatigue area and to predict punch fatigue life in cold forging operation for fastener. In particular, the number of life cycle, N of the die was predicted by using stress-life approach. The lifetime prediction was calculated based on the stress conditions in terms of the effective stress from the simulation of DEFORMTM F3 v 6.0. In addition, the stress-life formulation was computed into MATLAB programming to systematically estimate the fatigue life of cold forging die.**

Keywords— Punch life, Cold forging, Impact strength, Hardness and Tempering temperature, DEFORMTM F3 v 6.0 , MATLAB, ANSYS14 software.

I. INTRODUCTION

Tools for cold forging mainly fail due to cyclic fatigue. Tool costs can reach a significant portion of production costs and therefore methods to improve tool life are of high interest. However, tools are still mainly designed and optimized by the trial and error method.

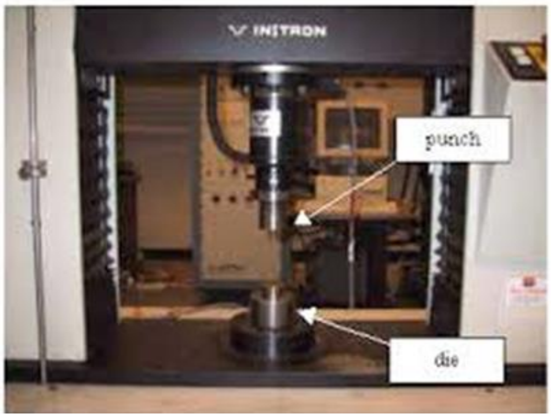
II. PROBLEM FORMULATION

During Cold Forging the metal is pressed under high pressure into high strength die, in which large strains are occurring on the workpiece. The die undergoes high cyclic loading.It has to resist heat abrasion and pressure .It has to withstand severe strains.The complexity in analysis die failure, die material selection, and the quality of forged component by CAD/CAM technology.

III. METHODOLOGY

In addition, the punch and die material behaviors of AISI D2 were used in simulation and stress life approach. Number of cold heading punch life cycle has been calculated in term of the modification sizes of corner radius of punch design. In the workpiece deformation analysis, the workpiece was modelled as a deformable body in order to determine the forging load of interaction between punch and deforming material, while the punch, bottom die and ejector pin were considered as a rigid body. On the other hand, for the die stress analysis, the punch of the die set was modelled as elastic body meanwhile the workpiece, bottom die and ejector pin were considered as rigid bodies to estimate the punch elastic deformation and the dimensional accuracy of forged component. The elastic deformation characteristic and stress concentration on heading punch were investigated to predict the number of fatigue life on the punch. The stainless steel SS 303 was used as workpiece material which offers excellent corrosion resistance in organic, acid, industrial as well as marine environments. The velocity of the punch is 200 mm/s, friction coefficient is 0.4, initial temperature of workpiece, punch and die temperature are 20 C, punch stroke is 25 mm, number of steps are 100 and the step increment is 10. The simulation step of the forged part produce from FE simulation is illustrated . The material properties for workpiece, die and punch chosen for the FE analysis.

IV. EXPERIMENTAL SET UP



Experimental Set Up-This testing machine will determine the strength of materials under the action of fatigue load. Specimens are subjected to repeated varying forces or fluctuating loading of specific magnitude while the cycles or stress reversals are counted to destruction. The first test is made at a stretch that is somewhat under the ultimate strength of the material. The second test is made at a stress that is less that than that used in the first. The process is continued, and results are plotted. The fatigue-testing machine is of the rotating beam type. The specimen functions as a single beam symmetrically loaded at two points. When rotated one-half revolution the stress in the fibres originally above the neutral axis of the specimen are reversed from compression to tension for equal intensity. Upon completing the revolution, the stresses are again reversed, so that during one complete revolution the test specimen passes through a complete cycle flexural stress. Here we are going to calculate fatigue life of cold forged punch analytically. Validate these results by using ANSYS14 software. The life of extrusion punches is very low as compared to other punches. Hence the aim of this paper is to improve the life of punch without increasing the punch production cost so much. The alternative punch material was selected from the available punch material as AISI D2 (Material B) against the conventional punch material AISI M2. This material has greater amount of cobalt, molybdenum and carbon than the conventional material.

V. PUNCH MATERIAL

Punch Material- AISID2 [2]
AISI : American Iron and Steel Institute D2 : For deep drawing quality (D1- For drawing quality and D3- For extra deep drawing quality).Type D2 is most widely used steel in United States for cold work tooling. It is air hardening steel. It contains very large chromium carbides which promotes abrasion resistance and excellent wear resistant characteristics. It has an outstanding record for freedom from cracking & minimal size change in hardening.[8]

Table1. Chemical composition of AISID2 steel (weight %) :

Elements	c	Si	Mn	Mo	Cr	Ni	V	Co	Fe
Weight %	1.5	0.3	0.3	1.0	15	0.3	0.8	1.0	79.8

Mechanical & Thermal properties of AISID2 tool steel at room temperature :
Density 7700Kg/m3
Poisson's ratio 0.27-0.3
Elastic modulus 1.9-2.1GPa
Tensile strength 1736MPa 0.2% offset
yield strength 1532MPa
Hardness (HRC) 57
Thermal expansion (at 20-100) 10.4 *10^{-6}

VI. PUNCH DIMENSIONS

The punch dimensions should be checked for strength & deflection. [9]
Punch length -The maximum allowable punch length (Lm) is calculated using following formula:
Lm = π D /8[(E*D)/ (fs*t)] 1/2
Where,
D=Diameter of punched hole
Fs=shear stress
t=material thickness
E=modulus of elasticity of punch material
Where D/t=1.1 or higher
Punch material should have sufficient compressive strength.
Punch Holder: Thickness varies between 25 to 75 mm.
Punch Plate: Thickness of punch plate =1.5*D
Both punch holder & punch plate are made of cast iron.

VII. MODELLING OF PUNCH

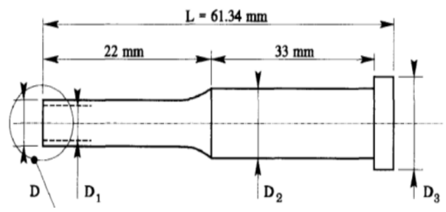


Fig. 1 : Punch geometry

Allowable shear stress-
fs=ultimate tensile strength/(2*factor of safety)
Fs= 1736/(2*8)=108.5N/mm2
Shear Force-
The force required to penetrate the stock material with the punch is the cutting force. The
formula for determining cutting forces takes into account the thickness of the work material, the perimeter of the cut edge, and the shear strength of the stock material. The cutting force is calculated below
Cutting/Shear force = (L x t x fs)=(ΩDtfs)
= Ω*15*3*108.5
=15338.83N
= 15.338 KN
Where,
L= perimeter of cut edge =ΩD
t = thickness of the work material
fs = shear strength of the stock material
Clearance -
Clearance is defined as the intentional space between the punch cutting edge and die cutting edge. Clearance is expressed as the amount of clearance per side.
Cutting Clearance = c x t x (√fs /10)
= 0.04 x 3x (√108.5/10) = 0.124 mm/side
Where
c = Constant = 0.04 for hard steel component.
t = thickness of the work material
fs = shear strength of the stock material
Maximum allowable punch length -
Lm=ΩD/8$(E/fs*D/t)^{1/2}$
=Ω*15/8$(209/108.5*15/3)^{1/2}$
=3.231 mm

VIII .SIMULATION PROCESS

Analysis Data:

Force: 15340 N
Punch length: 3.231 mm
D = 15mm
Unit area A = 3.14* 15* 1 = 47.1 sq. mm
Take punch load = 1.5 * actual force = 23010 N
Hence, pressure = 23010 / 47.1 = 488.53 N / sq.mm
Density = 7700Kg/m3
Poisson's ratio = 0.27- 0.3
Elastic modulus = 1.9 - 2.1GPa
Ultimate tensile strength = 1736MPa
Take FOS = 8
Allowable tensile strength = 1736/8 = 217 M Pa
Thermal expansion (at 20-100) 10.4 *10-6 / deg. C

Structural Analysis:

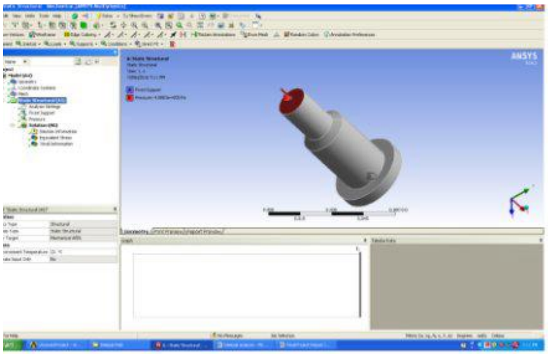


Fig .2. Structural Analysis

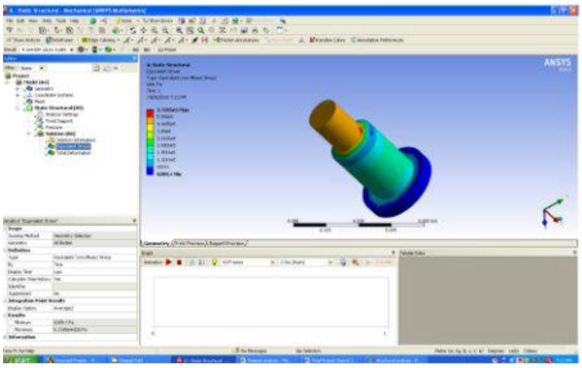


Fig.3 Stresses Induced

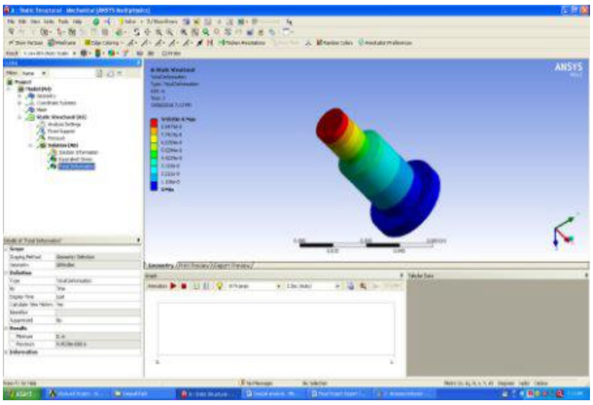


Fig 4. Structural Deformation

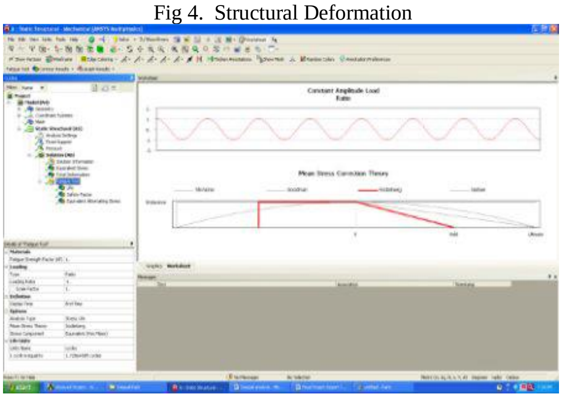


Fig 5 Fatigue Analysis

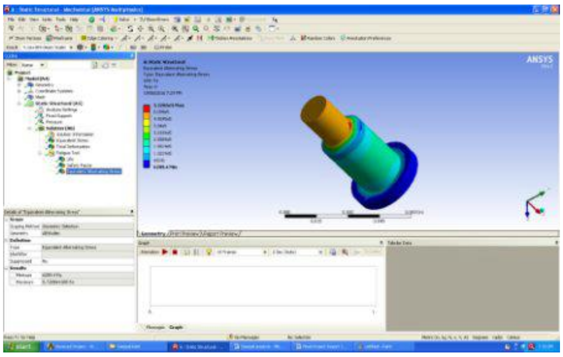


Fig 6 Fatigue Analysis (Alternate stress)

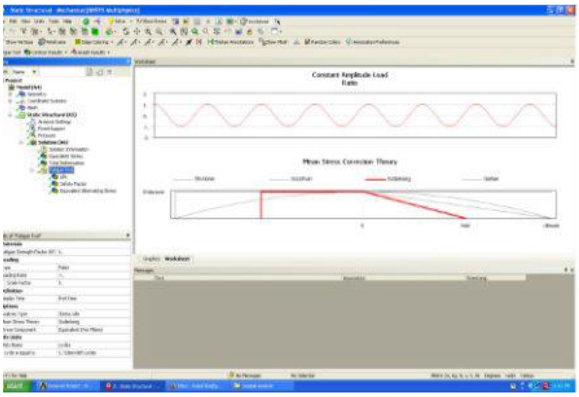


Fig.7 Goodman Diagram

IX. SIMULATION RESULTS

For both static & alternating loads both pressure & deformation are equal. The study and test conducted so far shows that fatigue failure cannot be predicted accurately Since material failure under fatigue are affected not by just reversal loading alone but also the number of revolution (cycle per minute). Fluctuating stress and other factors such as temperature, atmospheric condition. Both internal and external defect on material subjected under fatigue stress. Such defect includes notch, inclusion,stress concentration and non-homogeneity.

X. CONCLUSION

The fractured punches shows that failure occurred due to inability to withstand impact strength. Hence material having high impact property had been selected and material also checked for in which hardness and tempering temperature , impact strength is higher for material.

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